

## PERSPECTIVE OF TECHNOLOGICAL ACCEPTANCE MODEL TOWARD ELECTRIC VEHICLES

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### ABSTRACT

*The invention of electric vehicles (EVs) is a leap in the fields of automobile industry, rationalization of energy and conservation of the environment. This study focuses on adapting the model of acceptance of technology to identify consumer's behavior on the use of EV. The technology acceptance model was developed by Fred Davis (1989). The study community consists of 550 consumers from Amman city, the results show there is strong relation between independent variables (Perceived usefulness, Attitude toward using EV, Perceived ease of Use EV, Perceived the challenges of use) and the dependent variable (EV Use), where the value of the coefficient indicator is positive (0.415) and the value of the calculated F is (21.767), which is greater than the tabular value (2.89), and the moral value is (0.0), which is less than (0.05). This is an indicator that there is statistical impact for independent factors on consumer behavior.*

**KEYWORDS:** Electrical Vehicles, Attitude, Intention, Perceived & Behavior

**Received:** Jul 08, 2019; **Accepted:** Jul 28, 2019; **Published:** Sep 24, 2019; **Paper Id.:** IJMPERDOCT201977

### INTRODUCTION

Terrestrial transportation is one of the biggest contributors and the main cause of generating second carbon dioxide gas worldwide, particularly because of using vehicles with traditional fuel (Joskow et al., 1998).

Nowadays, there is strong tendency to begin and increase the use of EVs in transportation service, due to the huge increase in power consumption in essential and entertaining activities (Schonhoft and Holtmark, 2014).

In fact, many countries, besides that, are going towards clean nuclear power to reduce volumes of harmful gases' emissions to earth's atmosphere (Yuksel and Kaygusuz, 2011), Most car manufacturing companies are heading for manufacturing EVs to reduce gases' emissions that cause global warming, and to help in lightening and mitigation of the causes of thermionic emission and climate change.

EVs are considered to be new to Jordan (Ghoneim, 2018). Since they have little information about EVs, consumers are understandably afraid of using them. Moreover, EVs are expensive and durable commodities; so the purchasing decision is made as a result of comparison and other mental motives (Fosdyke, 2019). On the other hand, there are buyers who are willing to experiment new things and/or have a sense of social responsibility to preserve the environment and reduce pollution. Such consumers will go towards buying the EV considered as one of the promising alternatives to fight climate change through replacing traditional motors (internal combustion engines) by electric motors connected to carbon removals nets (Bleijenberg et al., 2013).

At the same time, EVs production contributes to providing many alternatives for consumers, which requires great effort from their side to collect information and do the comparison process in order to opt for the proper choice.

Like any new product, EVs have faced difficulty to find their way to the market and gain consumers' acceptance; especially in terms of safety (Root 1994). Though EV is green, a good friend to the environment, does not create noise, its use involves many difficulties. These include lack of stations to recharge power, recharge process, and recharge time duration and the distance that EV can operate with one recharge (Anfinsen, M., 2019).

In general, consumers may hesitate in taking the purchase decision for durable modern commodities, including EV, because they have no sufficient information and no previous experience with them (Alsamydai et al., 2014; Al-Samydai et al., 2019). However, there are many consumers who are willing to experience new things, including EVs. Also, production and marketing companies do not have enough information about the consumer acceptance of satisfaction with, reaction and attitude towards this type of vehicles.

Consequently, the present study attempts to identify the benefits and disadvantages of using EV from the consumer's perspective by adapting the technology acceptance model that focuses on the perceived usefulness, perceived ease of use, attitude and perceived behavioral intention affecting the buying behavior of EV.

### Study Objectives

The main objectives of this study are to be aware of the benefits of EV and the challenges that face its acceptance and approval of the Jordanian consumers by adapting the technology acceptance model. It is worth mentioning that EV has entered the Jordan market on commercial basis since 2014.

The objectives are to:

- Examine the effect of perceived usefulness and perceived ease of use on attitude toward using EV.
- Examine the effect of attitude toward using EV on intention of use EV.
- Examine the effect of use EV on behavioral intention.

### The Study Hypotheses

The technology acceptance model was developed by Fred Davis (1989). The model suggests that when users are presented with new technology, there are a number of factors which influence their decision about how and when they will use it.

The technology acceptance model has evolved to become a key model in understanding predictors of human behavior towards potential acceptance or rejection of the technology (Nikola and Andrina, 2014).

The technology acceptance model has been designed to show how users come to accept and use a technology. The theoretical basis is built on the premise that when users are presented with a new technology, three major factors influence their decision on how and when they will use it. The first determinant is its perceived usefulness; the second is the perceived ease of use, while the third determinant is user attitude towards usage. Since the EV is considered a newly-introduced product in the Jordanian market, we adapted this model to know challenges and benefits of the EV (David et al., 2017).

The Perceived usefulness is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance." This follows from the definition of the word useful: "capable of being used advantageously".

(Nunkoo et al., 2013) indicate that the perceived ease of use is defined as the degree, in which, a person believes that using a particular system would be free from effort.

The study hypothesizes that:

**H01:** There is no significant effect at the level of (0.05) of the (Perceived usefulness, Attitude toward using EV, Perceived ease of Use EV, Perceived the challenges of use) and Intention of Use EV.

**H02:** There is no significant effect at the level of (0.05) between Intention of Use EV and Behavior of Use EV.

## Study Model

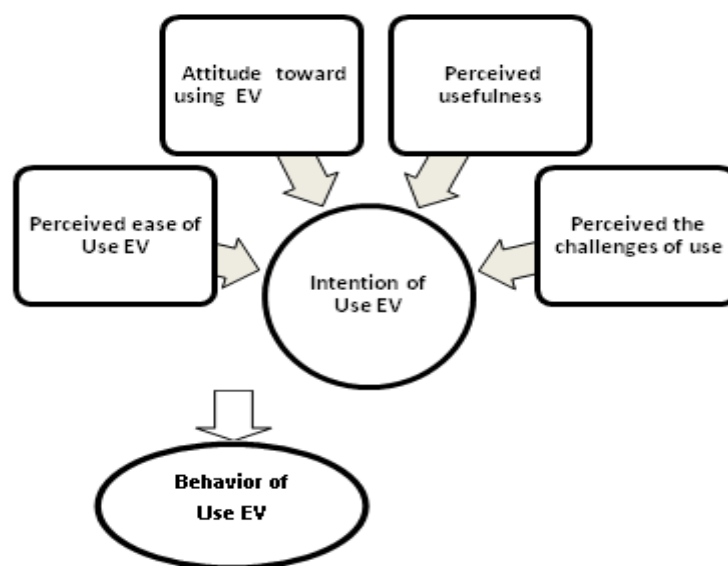


Figure 1

## Development of EV Industry

Vehicles industry sector witnessed a great development, especially when stock holders realized that there were problems in fuel costs and environmental pollution, which pushed them to develop the vehicle towards efficiency in fuel consumption and reduction of gases' emissions. They found that this could be achieved by entering hybrid vehicles and EVs to their production lines.

EVs first appeared in the middle of 19th century. An EV held the vehicular land speed record until around 1900. The high cost, low top speed, and short range of battery EVs, compared to later internal combustion engine vehicles, led to a worldwide decline in their use. (Thompson, 2015)

One of the reasons, that stood against production and marketing release of electric car in that period, 1912, was that electric starters were developed, which made the great disadvantage of the hand crank disappear and boosted the sales of gasoline-powered cars, and electricity was still not accessible in most of the rural areas at that time. Finally around 1935, the electric cars were ultimately beaten by the combustion-engine cars and disappeared for a long time from the market (Matulka, 2014).

At the beginning of the 21st century, interest in electric and other alternative fuel vehicles has increased due to growing concern over the problems associated with hydrocarbon-fueled vehicles, including damage to the environment

caused by their emissions and the sustainability of the current hydrocarbon-based transportation infrastructure as well as improvements in EV technology. Since 2010, combined sales of all-electric cars and utility vans achieved 1 million units delivered globally, and combined global sales of light-duty all-electrics and plug-in hybrids reached 4 million in September 2018 (Shahan, 2016; Posawatz 2018; Denning 2018).

In the last few years, annual global sales of EVs were rising strongly; from few hundred in 2010 to more than 500,000 in 2015, and to more than 750,000 in 2016. The accumulative global market reached a distinct milestone to hit one million cars. From there it rose quickly to two million cars in January 2017 (Lingzhi 2017; Peter, 2017).

All EVs are sold with home charger that worked with ordinary electric current (AC-240V). Most of chargers need from 8 to 9 hours to fully charge the battery. Some home chargers can reduce this period to six hours by using a higher current Ampere.



**Figure 2: Charging an Electric Car at Home (Fosdyke, J. 2019).**

Most of EVs use lithium-ion battery or Li-ion battery (abbreviated as LIB).

LIBs are environment friendly and have higher power capacity and have more power age than the traditional batteries. (Ganji and Kouzani, 2010)

Most of EVs are provided with fast (speedily) charging entry that uses DC; and it needs special stations to shorten or reduce charging process to half an hour or a little bit more.

### **Previous Studies**

(Bunce et al., 2014) mentions that personal preferences changes with great scale after a real experience with the EV, especially what concerns preferring driving range, maximum speed, fuel cost, battery age and charging the battery in city centers.

Yongyou et al 2018, explains that vehicles' buyers, in Shanghai, prefer to drive vehicles with long distance range, shorter charging time, faster maximum speed, less pollution emissions, reducing in fuel cost and price.

Results of previous research indicate that consumers have numerous concerns including range, access to rechargers, charging time, price premium, vehicle purchase price, fuel price and fuel efficiency, brand and segment supply.

Cluzel, Standen Ivan et al 2015, demonstrate that environmental concerns and the perception of environmental policy are antecedent factors of the perception of full EVs, which influences the behavioral intention to purchase full EVs, and the perception of economic benefit is one of the key factors influencing the adoption of full EVs. Vehicle operators seek economic benefits from future long-term fuel savings, high energy efficiency, and cheap electricity.

Alan Jenna et al 2018, indicate that the most important location for plug-in electricity vehicle (PEV) charging is at home, followed by work, and then public locations. The studies have found that more effort is needed to ensure that consumers have easy access to PEV charging and that charging at home, work, or public locations should not be free of cost.

Kenneth et al 1996, state that the limited range and long recharging times seem to impede EV (EV) adoption. On the other hand, EVs can easily be charged at home for most car owners, potentially yielding more comfort since extra visits to gas stations become unnecessary.

Pearre et al 2011, mention that the limited electric driving range, of battery EVs, is technically and mentally, a major hurdle for many consumers and impacts the EVs utility. The variation in distances travelled by one individual on different days of the year is important for the utility of EVs.

Stations for charging EVs are available but the problem is vehicle recharge time that may take 20 minutes in the station with no full recharge, and if there is a queue of five vehicles, then he needs to wait for 100 minutes to recharge his vehicle.

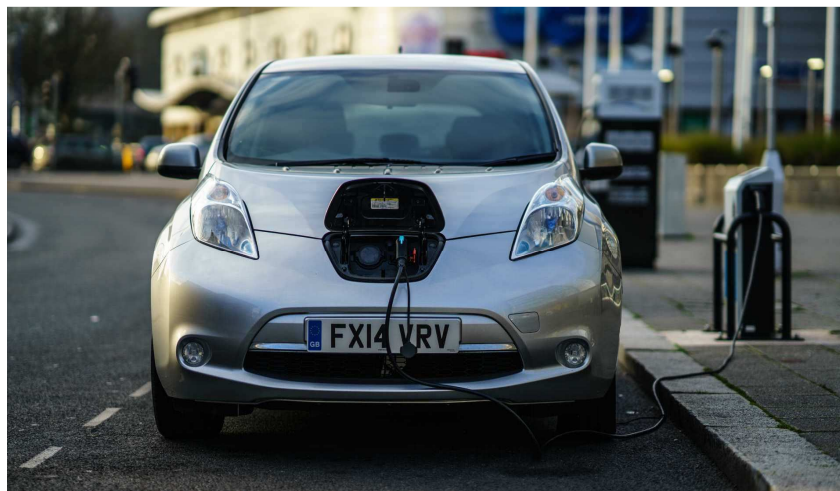


Figure 3: Public Electric Car Charging Station (Fosdyke, J. 2019).

## RESULTS AND RELIABILITY STATISTICS

### Study Methodology

#### Resources of Information

The present writer depends on books and researches, related to the subject of the study in order to give clear idea about technology acceptance model, its variables, then to adapt the model in a way to be compatible with the study nature and design the questionnaire accordingly.

The questionnaire included 34 questions divided into six dimensions. The first dimension is about vehicle perceived benefits and includes seven questions. The second dimension has four questions about attitudes concerning EV.

The third dimension includes five questions about the ease of use. The fourth dimension consists of seven questions about the perceived risks of EV. The fifth dimension has six questions about behavioral intention towards EV. The sixth dimension includes five questions about the expected behavior.

Like Likert Scale which consists of the following five degrees (Strongly Agree, Agree, Neutral, Disagree, Strongly disagree), is utilized in the study.

### Sample and study community

The study community consists of consumers (customers), from Amman city. The sample was chosen from 550 consumers, and we collected 424 valid questionnaire copies for statistical analysis, with percentage of 77 %.

### Tool Stability

In order to investigate the study tool stability and to measure internal consistency of questionnaire components, the author uses consistency factor (Cronbach's Alpha). The consistency percentage for the overall tool reaches (81%) which is an excellent percentage because it is higher than the accepted percentage of (70%).

Table 1 is about the dependent variables, shown and explained below:

**Table 1: Anova<sup>a</sup>**

Model	R	R Square	Df	F	Sig.
1	0.415 <sup>a</sup>	0.172	4/418/422	21.767	0.000 <sup>b</sup>

a. Dependent Variable: h5att

b. Predictors: (Constant), h4pr, h3eu, h1pb, h2at

Table 1 shows the research dependent variables (Perceived usefulness, Attitude toward using EV, Perceived ease of Use EV, Perceived the challenges of use), and Intention of Use EV.

Dependent variables are significant, because **F** significant is (0.00) which is less than (0.05), and the calculated **F** value (21.767) is more than **F** table value (2.89). Therefore, we reject the null hypothesis and accept the alternative one which states that **there is statistically significant effect at the level of ( $\alpha \leq 0.05$ )** of the Perceived usefulness, Attitude toward using EV, Perceived ease of Use EV, Perceived the challenges of use), and Intention of Use EV.

The relationship between the dependent and independent variables is positive.

$R = 0.415^a$  Also, the  $R^2 = 0.172$ , which means that the independent variables contribution strongly effect the dependent variables with percentage of 172%.

In the following Table 2:

**Table 2: Anova<sup>a</sup>**

Model	R	R Square	df	F	Sig.
1	0.141 <sup>a</sup>	0.020	1/421/422	8.548	0.004 <sup>b</sup>

a. Dependent Variable: h6exp

b. Predictors: (Constant), h5att

Table 2, shows the research dependent variables (Perceived usefulness, Attitude toward using EV, Perceived ease of Use EV, Perceived the challenges of use), and Intention of EV Use.

The variables are significant, because **F** significant is (0.00), which is less than (0.05), and the calculated **F** value (21.767) is more than **F** table (2.89). Therefore we reject the null hypothesis and accept the alternative one which states



that there is statistically significant effect at the level of ( $\alpha \leq 0.05$ ) of the Perceived usefulness, Attitude toward using EV, Perceived ease of Use EV, Perceived the challenges of use), and Intention of Use EV.

The relationship between the dependent and independent variables is positive;  $R = 0.415^a$ ; Also, the  $R^2 = 0.172$ , which means that the independent variables contribution strongly effect the dependent variables with percentage of 172%.

**Table 3: Perceived the Challenges of use One-Sample Statistics**

Perceived the challenges of use	M	R	Std.	t	Sig
You think the information you have, about the electric vehicle, is not enough	4.24	2	.739	34.70	.000
You think that you are concerned about the power of the electric vehicle will run out of charge, which causes you not to buy it	4.05	4	.920	23.55	.000
You think that charging electric car takes a long time, which causes you not to buy it	3.74	7	.980	15.66	.000
You believe that setting up electricity at home to charge electric car is expensive, which means you do not buy it	3.57	8	1.153	10.24	.000
You believe that the number of electric car charging stations are few within Amman and it is one of the obstacles to buying an electric car	4.33	1	.882	31.18	.000
You believe that the electric vehicle does not allow you to travel to neighboring province because of insufficient charging	4.21	3	.898	27.75	.000
There is a lack of confidence in maintenance centers of electric cars because it is a new vehicle	4.01	5	.566	36.93	.000

M; Mean, R; Range, Std; Stander Deviation, t; Tabulated t Test, Sig; Significant

The great challenge that faces consumers using electric vehicle is the recharging problem. Table (3) shows that non availability of enough numbers of recharging stations, in Amman city, is one of the major obstacles for purchasing EV with an average of (4.3381). The reason behind this obstacle is that it will cause many troubles for the owner or the user, for example being late to appointments or work, causing traffic jam and paying the cost of towing the vehicle to the nearest maintenance station.

In the second place comes the consumers' lack of information about EVs or electric vehicle, which makes persuading them to buy the cars all the more difficult.

Most of EV users own cars with fair and suitable prices, but the distance range that EV covered is not enough to move between governorates, which may lead to worrying feelings while driving for long distances because the recharging stations are not available on the road.

**Table 4: Behavior of use Electric Vehicle One-Sample Statistics**

Behavior of use Electric Vehicle	M	R	Std.	t	Sig
You feel lack of trust in maintenance centers, because the electric car is new	3.79	4	.529	30.81	.000
You find that your decision to buy electric car will be right	4.03	2	.699	30.33	.000
You will feel proud when buying an electric car, because it is environmentally friendly	3.51	5	.712	14.77	.000
You find that using an electric car is easy and enjoyable, which encourages you to buy it	4.01	3	.566	36.93	.000
You think to buy an electric car because it is energy-saving	4.18	1	.461	52.85	.000

M; Mean, R; Range, Std; stander Deviation, t; tabulated t test, Sig; significant

Table (4), shows one of the most important factors that affects the purchasing behavior of the customer (consumer) is the power or recharging availability with an average of (4.1852), and the "right decision" comes in the second degree with average of (4.0319).

Since the value of the calculated t value for the variables you feel lack of trust in maintenance centers, because the electric car is new (30.812), you find that your decision to buy electric car will be right (30.3350), you will feel proud when buying an electric car, because it is environmentally friendly (14.773), you find that using an electric car is easy and enjoyable, which encourages you to buy it (36.938) and, you think to buy an electric car because it is energy-saving (52.850) are more than the t value table (1.96) and the Sig 0.000, this means they have statistically significant effect on the dependent variables.

## DISCUSSIONS

The most important factor that leads consumers to buy EV is saving power consumption, but electric car users are facing recharging process problems because there are not enough recharging power stations. If the time of recharging a car takes 20 minutes and if there is a queue with five vehicles, then it takes 100 minutes for a person to recharge his vehicle. This is considered a waste of time and creates great psychological pressure on him. Also, there are no charging stations outside Amman and on highways, which deprives EV users of commuting outside Amman, because most of EVs have range of 120 to 170 km as the attained maximum distance. Some of the sample people find that the unavailability of enough charging stations is one of the major obstacles to buy EV. Looking for charging stations, long periods of waiting to recharge and in some cases no full charging, are other obstacles for buying EV. In addition to that, the increasing custom's fees and cancellation of custom's exemption, contribute in rising of EV prices.

Yong you et al 2018, indicate that repliers prefer EVs of long distance range, less charging time, higher maximum speed, low pollution emissions, reduce fuel cost and reduction in prices.

Also, results show impact for (Perceived usefulness, Attitude toward using EV, Perceived ease of Use EV, and Perceived the challenges of use) on Intention of Use EV. And Intention of Use EV has an impact on the behavior of EV Use.

Moreover, there is strong relation between independent and dependent variables, where the value of the coefficient indicator is positive (0.415) and the value of the calculated F is (21.767), which is greater than the tabular value (2.89), and the moral value is (0.0), which is less than (0.05). This is an indicator that there is statistical impact for independent factors on consumer behavior.

The results also show that the most important factor that affects the buying behavior of EV consumer is power availability. Another obstacle that faces consumers is that they do not have enough, detailed, and integrated information about EVs that may help to make the purchase decision. Therefore, it is the responsibility of producers and marketers of EVs to intensify their advertising campaigns and provide full information to consumers to ease and facilitate purchasing process for them.

At the same time, they have to work on solving the problems of charging stations availability. Recharging at home needs an infrastructure for charging station at home; it needs to be changed from one phase to three-phase capacity. This is also a problem because it requires asking the electricity company to provide the service, and paying the costly charges of the process. In fact, most people are living in rented houses, so they have to do this process each time they move to a new house. It is a major obstacle indeed. The focus must be on increasing the number of charging stations which will facilitate the EV use.



A 42% of the sample individuals have intention to buy electric vehicles in the future, because it preserves the environment, which agrees with the study.

Ivan et al 2015, explain that environmental scares and awareness of environmental policies are from the factors preceding the concept of complete EV that have an impact on behavioral intention of buying complete EV.

Yong you et al, 2018, found that respondents preferred EVs with longer driving range, shorter charging time, faster maximum speed, lower pollution emissions, lower fuel cost and lower price.

## CONCLUSIONS

The current study applied TAM model to examine the factors of usefulness, attitude, and ease of Use EV, challenges of use and Intention of Use EV that influencing consumer's acceptance and use of Electric Vehicles.

This study found that the great challenge that faces consumers using electric vehicle is the recharging problem. Table (3) shows that non availability of enough numbers of recharging stations, in Amman city, is one of the major obstacles for purchasing EV with an average of (4.3381). The reason behind this obstacle is that it will cause many troubles for the owner or the user, for example being late to appointments or work, causing traffic jam and paying the cost of towing the vehicle to the nearest maintenance station and In the second place comes the consumers' lack of information about EVs or electric vehicle, which makes persuading them to buy the cars all the more difficult, also findings that one of the most important factors that affects the purchasing behavior of the customer (consumer) is the power or recharging availability with an average of (4.1852), and the "right decision" comes in the second degree with average of (4.0319), the consumer buy an electric car because it is energy-saving.

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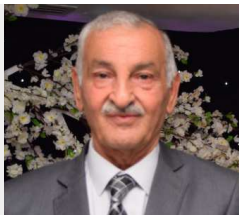
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